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Badger Army Ammunition Plant
Baraboo
Sauk County
Wisconsin

HAER No. WI-8

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, DC 20013-7127

HISTORIC AMERICAN ENGINEERING RECORD

Badger Army Ammunition Plant

WI-8

Location:	The Sauk County, Wisconsin, on the Sauk Prairie of South-Central Wisconsin, between the Baraboo Range and the Wisconsin River.
Date of Construction:	Established in 1942.
Owner:	Department of the Army
Significance:	Established during World War II, Badger Army Ammunition Plant was one of six similar smokeless powder plants constructed between 1940 and 1943 for the U.S. Army.
Historical Report Prepared by:	David Fay, 1984
Prepared for Transmittal by:	Robie S. Lange, HABS/HAER, 1985.

EXECUTIVE SUMMARY

The Badger Army Ammunition Plant (BAAP) is a government-owned, contractor-operated (GOCO) propellant plant located midway between Baraboo and Sauk City, Wisconsin. The installation is a part of the Army's Armament, Munitions and Chemical Command (AMCCOM). One of six very similar smokeless powder plants constructed between 1940 and 1943 for the U.S. Army, the BAAP was expanded during the Korean and Vietnam wars, and is currently on standby and modernization status. Modernization activities include the construction of improved waste-handling facilities and the limited modification of existing production equipment. Present facilities include production lines for single-base smokeless powder, double-base propellant, smokeless ball powder, nitrocellulose, nitroglycerine, sulphuric and nitric acid, and a variety of solvents. The current operating contractor is Olin Corporation.

The 7,417-acre site presently contains 1,612 buildings, 1,338 of which were constructed during World War II and house equipment from that era. The majority of the buildings were constructed for temporary use and are utilitarian in nature. There are no Category I or II historic properties at the BAAP. The Ball Powder facilities constructed during 1954-55 -- a good example of a highly intact industrial process, and the only such facilities at a GOCO plant in the United States -- are Category III historic properties.

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PREFACE

This report presents the results of an historic properties survey of the Badger Army Ammunition Plant (BAAP). Prepared for the United States Army Materiel Development and Readiness Command (DARCOM), the report is intended to assist the Army in bringing this installation into compliance with the National Historic Preservation Act of 1966 and its amendments, and related federal laws and regulations. To this end, the report focuses on the identification, evaluation, documentation, nomination, and preservation of historic properties at the BAAP. Chapter 1 sets forth the survey's scope and methodology; Chapter 2 presents an architectural, historical, and technological overview of the installation and its properties; and Chapter 3 identifies significant properties by Army category and sets forth preservation recommendations. Illustrations and an annotated bibliography supplement the text.

This report is part of a program initiated through a memorandum of agreement between the National Park Service, Department of the Interior, and the U.S. Department of the Army. The program covers 74 DARCOM installations and has two components: 1) a survey of historic properties (districts, buildings, structures, and objects), and 2) the development of archaeological overviews. Stanley H. Fried, Chief, Real Estate Branch of Headquarters DARCOM, directed the program for the Army, and Dr. Robert J. Kapsch, Chief of the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) directed the program for the National Park Service. Sally Kress Tompkins was program manager, and Robie S. Lange was

project manager for the historic properties survey. Technical assistance was provided by Donald C. Jackson.

Building Technology Incorporated acted as primary contractor to HABS/HAER for the historic properties survey. William A. Brenner was BTI's principal-in-charge and Dr. Larry D. Lankton was the chief technical consultant. Major subcontractors were the MacDonald and Mack Partnership and Jeffrey A. Hess. The author of this report was David Fey. The author gratefully acknowledges the administrative assistance of Donald L. Hartmann, of the government staff; and the research assistance of Robert Bobrowicz and the on-site guidance of Don G. Stoll, both of Olin Corporation.

The complete HABS/HAER documentation for this installation will be included in the HABS/HAER collections at the Library of Congress, Prints and Photographs Division, under the designation HAER No. WI-8.

Chapter 1

INTRODUCTION

SCOPE

This report is based on an historic properties survey conducted in July 1983 of all Army-owned properties located within the official boundaries of the Badger Army Ammunition Plant (BAAP). The survey included the following tasks:

- Completion of documentary research on the history of the installation and its properties.

- Completion of a field inventory of all properties at the installation.

- Preparation of a combined architectural, historical, and technological overview for the installation.

- Evaluation of historic properties and development of recommendations for preservation of these properties.

Also completed as a part of the historic properties survey of the installation, but not included in this report, are HABS/HAER Inventory cards for 42 individual properties. These cards, which constitute HABS/HAER Documentation Level IV, will be provided to the Department of the Army. Archival copies of the cards, with their accompanying photographic

negatives, will be transmitted to the HABS/HAER collections at the Library of Congress.

The methodology used to complete these tasks is described in the following section of this report.

METHODOLOGY

1. Documentary Research

The BAAP was one of six government-owned propellant plants constructed during the period 1940-1943. Because it was part of an extensive manufacturing network, an understanding of its historical and technological significance requires a general understanding of the wartime munitions industry. To identify published documentary sources on the American munitions industry during World War II, and the Korean and Vietnam wars, research was conducted in standard bibliographies of military history, engineering, and the applied sciences. Unpublished sources were identified by researching the historical and technical archives of the U.S. Army Armament, Munitions and Chemical Command (AMCCOM) at Rock Island Arsenal.[1]

In addition to this general research, a concerted effort was made to locate published and unpublished material dealing specifically with the history and technology of the BAAP. This site-specific research was conducted primarily at the AMCCOM Historical Office at Rock Island

Arsenal, the Baraboo Public Library, and the government and contractor files at the BAAP.

Army records used for the field inventory included current Real Property Inventory (RPI) printouts that listed all officially recorded buildings and structures by facility classification and date of construction; the installation's property record cards; base maps and photographs supplied by installation personnel; and installation master planning, archaeological, environmental assessment, and related reports and documents. A complete listing of this documentary material may be found in the bibliography.

2. Field Inventory

The field inventory was conducted in July 1983 by David Fey and Robert Ferguson. Donald Hartmann provided administrative assistance, Robert Bobrowicz provided research assistance, and Don Stoll guided the on-site inspections.

Field inventory procedures were based on the HABS/HAER Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures.[2] All areas and properties were visually surveyed. Building locations and approximate dates of construction were noted from the installation's property records and field-verified. Interior surveys were made of the major facilities to permit adequate evaluation of architectural features, building technology, and production equipment.

Field inventory forms were prepared for, and black and white 35 mm photographs taken of all buildings and structures through 1945 except basic utilitarian structures of no architectural, historical, or technological interest. When groups of similar ("prototypical") buildings were found, one field form was normally prepared to represent all buildings of that type. Field inventory forms were also completed for representative post-1945 buildings and structures.[3] Information collected on the field forms was later evaluated, condensed, and transferred to HABS/HAER Inventory cards.

3. Historical Overview

A combined architectural, historical, and technological overview was prepared from information developed from the documentary research and the field inventory. It was written in two parts: 1) an introductory description of the installation, and 2) a history of the installation by periods of development, beginning with pre-military land uses. Maps and photographs were selected to supplement the text as appropriate.

The objectives of the overview were to 1) establish the periods of major construction at the installation, 2) identify important events and individuals associated with specific historic properties, 3) describe patterns and locations of historic property types, and 4) analyze specific building and industrial technologies employed at the installation.

4. Property Evaluation and Preservation Measures

Based on information developed in the historical overviews, properties were first evaluated for historical significance in accordance with the eligibility criteria for nomination to the National Register of Historic Places. These criteria require that eligible properties possess integrity of location, design, setting, materials, workmanship, feeling, and association, and that they meet one or more of the following:[4]

A. Are associated with events that have made a significant contribution to the broad patterns of our history.

B. Are associated with the lives of persons significant in the nation's past.

C. Embody the distinctive characteristics of a type, period, or method of construction, represent the work of a master, possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction.

D. Have yielded, or may be likely to yield, information important in pre-history or history.

Properties thus evaluated were further assessed for placement in one of five Army historic property categories as described in Army Regulation 420-40:[5]

Category I	Properties of major importance
Category II	Properties of importance
Category III	Properties of minor importance
Category IV	Properties of little or no importance
Category V	Properties detrimental to the significance of adjacent historic properties.

Based on an extensive review of the architectural, historical, and technological resources identified on DARCOM installations nationwide, four criteria were developed to help determine the appropriate categorization level for each Army property. These criteria were used to assess the importance not only of properties of traditional historical interest, but also of the vast number of standardized or prototypical buildings, structures and production processes that were built and put into service during World War II, as well as of properties associated with many post-war technological achievements. The four criteria were often used in combination and are as follows:

1) Degree of importance as a work of architectural, engineering, or industrial design. This criterion took into account the qualitative factors by which design is normally judged: artistic merit, workmanship, appropriate use of materials, and functionality.

2) Degree of rarity as a remaining example of a once widely used architectural, engineering, or industrial design or process. This criterion was applied primarily to the many standardized or prototypical DARCOM buildings, structures, or industrial processes. The more widespread or influential the design or process, the greater the importance of the remaining examples of the design or process was considered to be. This criterion was also used for non-military structures such as farmhouses and other once prevalent building types.

3) Degree of integrity or completeness. This criterion compared the current condition, appearance, and function of a building, structure, architectural assemblage, or industrial process to its original or most historically important condition, appearance, and function. Those properties that were highly intact were generally considered of greater importance than those that were not.

4) Degree of association with an important person, program, or event. This criterion was used to examine the relationship of a property to a famous personage, wartime project, or similar factor that lent the property special importance.

The majority of DARCOM properties were built just prior to or during World War II, and special attention was given to their evaluation. Those that still remain do not often possess individual importance,

but collectively they represent the remnants of a vast construction undertaking whose architectural, historical, and technological importance needed to be assessed before their numbers diminished further. This assessment centered on an extensive review of the military construction of the 1940-1945 period, and its contribution to the history of World War II and the post-war Army landscape.

Because technology has advanced so rapidly since the war, post-World War II properties were also given attention. These properties were evaluated in terms of the nation's more recent accomplishments in weaponry, rocketry, electronics, and related technological and scientific endeavors. Thus the traditional definition of "historic" as a property 50 or more years old was not germane in the assessment of either World War II or post-war DARCOM buildings and structures; rather, the historic importance of all properties was evaluated as completely as possible regardless of age.

Property designations by category are expected to be useful for approximately ten years, after which all categorizations should be reviewed and updated.

Following this categorization procedure, Category I, II, and III historic properties were analyzed in terms of:

- Current structural condition and state of repair. This information was taken from the field inventory forms and

photographs, and was often supplemented by rechecking with facilities engineering personnel.

- The nature of possible future adverse impacts to the property. This information was gathered from the installation's master planning documents and rechecked with facilities engineering personnel.

Based on the above considerations, the general preservation recommendations presented in Chapter 3 for Category I, II, and III historic properties were developed. Special preservation recommendations were created for individual properties as circumstances required.

5. Report Review

Prior to being completed in final form, this report was subjected to an in-house review by Building Technology Incorporated. It was then sent in draft to the subject installation for comment and clearance and, with its associated historical materials, to HABS/HAER staff for technical review. When the installation cleared the report, additional draft copies were sent to DARCOM, the appropriate State Historic Preservation Officer, and, when requested, to the archaeological contractor performing parallel work at the installation. The report was revised based on all comments collected, then published in final form.

NOTES

1. The following bibliographies of published sources were consulted: Industrial Arts Index, 1938-1957; Applied Science and Technology Index, 1958-1980; Engineering Index, 1938-1983; Robin Higham, ed., A Guide to the Sources of United States Military History (Hamden, Conn.: Archon Books, 1975); John E. Jessup and Robert W. Coakley, A Guide to the Study and Use of Military History (Washington, D.C.: U.S. Government Printing Office, 1979); "Military Installations," Public Works History in the United States, eds., Suellen M. Hoy and Michael C. Robinson (Nashville: American Association for State and Local History, 1982), pp. 380-400. AMCCOM (formerly ARRCOM, or U.S. Army Materiel Readiness Command) is the military agency responsible for supervising the operation of government-owned munititions plants; its headquarters are located at Rock Island Arsenal, Rock Island, Illinois. Although there is no comprehensive index to AMCCOM archival holdings, the agency's microfiche collection of unpublished reports is itemized in ARRCOM, Catalog of Common Sources, Fiscal Year 1983, 2 vols. (no pl.: Historical Office, AMCCOM, Rock Island Arsenal, n.d.).

2. Historic American Buildings Survey/Historic American Engineering Record, National Park Service, Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures (unpublished draft, 1982).

3. Representative post-World War II buildings and structures were defined as properties that were: (a) "representative" by virtue of construction type, architectural type, function, or a combination of these, (b) of obvious Category I, II, or III historic importance, or (c) prominent on the installation by virtue of size, location, or other distinctive feature.

4. National Park Service, How to Complete National Register Forms (Washington, D.C.: U.S. Government Printing Office, January 1977).

5. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).

Chapter 2

HISTORICAL OVERVIEW

BACKGROUND

The Badger Army Ammunition Plant (BAAP) is located on the Sauk Prairie of south-central Wisconsin, between the Baraboo Range and the Wisconsin River. Settled in the 1840's, this tract of rich prairie land was farmed intensively until its acquisition by the Army in 1942. The original plans for the Badger Ordnance Works (now BAAP) called for three smokeless powder production lines, as well as support facilities to manufacture diphenylamine and sulphuric acid. Construction began in February 1942 and continued throughout World War II, as expanded plans called for additional smokeless powder facilities and added production areas for double-base rocket propellant and nitric acid. TNT facilities and an additional smokeless powder line, under construction when the plant was shut down in 1945, were never completed.

Following World War II the plant was placed on standby status. Rehabilitation for the Korean War began in February of 1951, and was completed in 1954. New facilities were constructed, and some existing ones modified, for the production of Ball Powder during 1954 and 1955. The plant was placed on standby status again on November 18, 1959, and remained inactive until March 28, 1966. Reactivation for the Vietnam War included the modernization of existing structures and equipment as well as limited new construction. Since 1975 the plant has been on standby and modernization status. At present the plant comprises 7,417 acres and 1,612 structures.

With the exception of minor alterations undertaken in the course of routine maintenance and modernization, the plant's World-War-II-era buildings and equipment remain largely intact.

For a more detailed understanding of the plant's architectural and technological history, it is necessary to look more closely at the site's three major production periods: World War II, the Korean War, and the Vietnam War.

WORLD WAR II PERIOD

As the probable involvement of the United States in World War II became increasingly evident, the Army established an office in Wilmington, Deleware, to oversee the planning and construction of new munitions-manufacturing facilities. The office, opened on July 1, 1937, studied the productive capacity of the nation's existing munitions plants and prepared estimates of future demand for powder and explosives. In collaboration with the Dupont and Hercules corporations, the office devised standard plans for the construction of smokeless powder and high explosive plants and selected possible sites for the new facilities.[1]

Site Selection and Former Land Use

The government's criteria for the siting explosives plants in general, and smokeless powder plants in particular, greatly limited the number of possible locations. The basic criteria included: distance from coasts and foreign borders; accessibility by two existing rail lines; proximity to a

large workforce; stable geology; and availibility of ample water and electricity.[2] The Sauk Prairie site was one of six sites selected in 1940 and 1941 for smokeless powder plants.[3] Its location on the Wisconsin River, its proximity to several medium-sized communities, its accessibility to both the Milwaukee Road and the Chicago & Northwestern railroads, and the excellent load-bearing characteristics of its geology made it an ideal site.

German and Swiss immigrants first settled the Sauk Prairie in the 1840s. By March of 1942, when the government officially took possession of this prosperous agricultural land, there were 79 individual farms on the site, including over 800 houses and other buildings, as well as three cemeteries.[4] All but 85 of the buildings were sold at public auctions and moved; the remaining buildings served as temporary offices and warehouses while the plant was under construction. Crop and fencing sales were also held to clear the land prior to construction.[5] No pre-1942 buildings still stand, but the three cemeteries have been preserved and are accessible to the public.

Construction

The Hercules Powder Company, having just designed and constructed a similar plant near Radford, Virginia, designed the BAAP and supervised its construction and operation. The Mason & Hanger Company of New York, which had served as the architect-engineer-manager (AEM) at Radford, performed the same services at the BAAP. Construction began with the extension of a spur line onto the site by the Chicago & Northwestern Railroad on February 1,

1942. Hercules established a field office in Baraboo on February 13, and awarded the first building contract on March 12.[6]

The layout of the plant was organized into self-contained production areas connected by a grid of access roads and rail lines (Figure 1). The administrative and service buildings, including the main offices, garages, change houses, cafeteria, and hospital, are located along the west side of the site, where they are accessible from Highway 12. The raw material warehouses and preliminary processing buildings of the single-base smokeless powder lines are located immediately to the east of these buildings, and the lines proceed to the east, allowing small distances between safer production steps and correspondingly larger spaces between more hazardous ones. Acid and solvent works are located to the north of the single-base powder lines; the nitroglycerine area lies to the east. The rocket area (double-base smokeless powder lines) is south and west of the single-base lines, and the powder storage magazines are beyond the rocket area, to the south. The water filtration plant and storage reservoirs are on the bluffs at the north side of the site, where the natural elevation provides system pressure.

The buildings constructed during World War II were simple, utilitarian structures designed for temporary use. They took different forms because of their varied structural and functional requirements. Most of the buildings, however, were wood-frame structures on either a cement slab or a perimeter foundation wall as described in a report prepared by Hercules:

> A typical building was constructed with 8" monolithic concrete foundations. The foundation wall was carried 6" above the floor

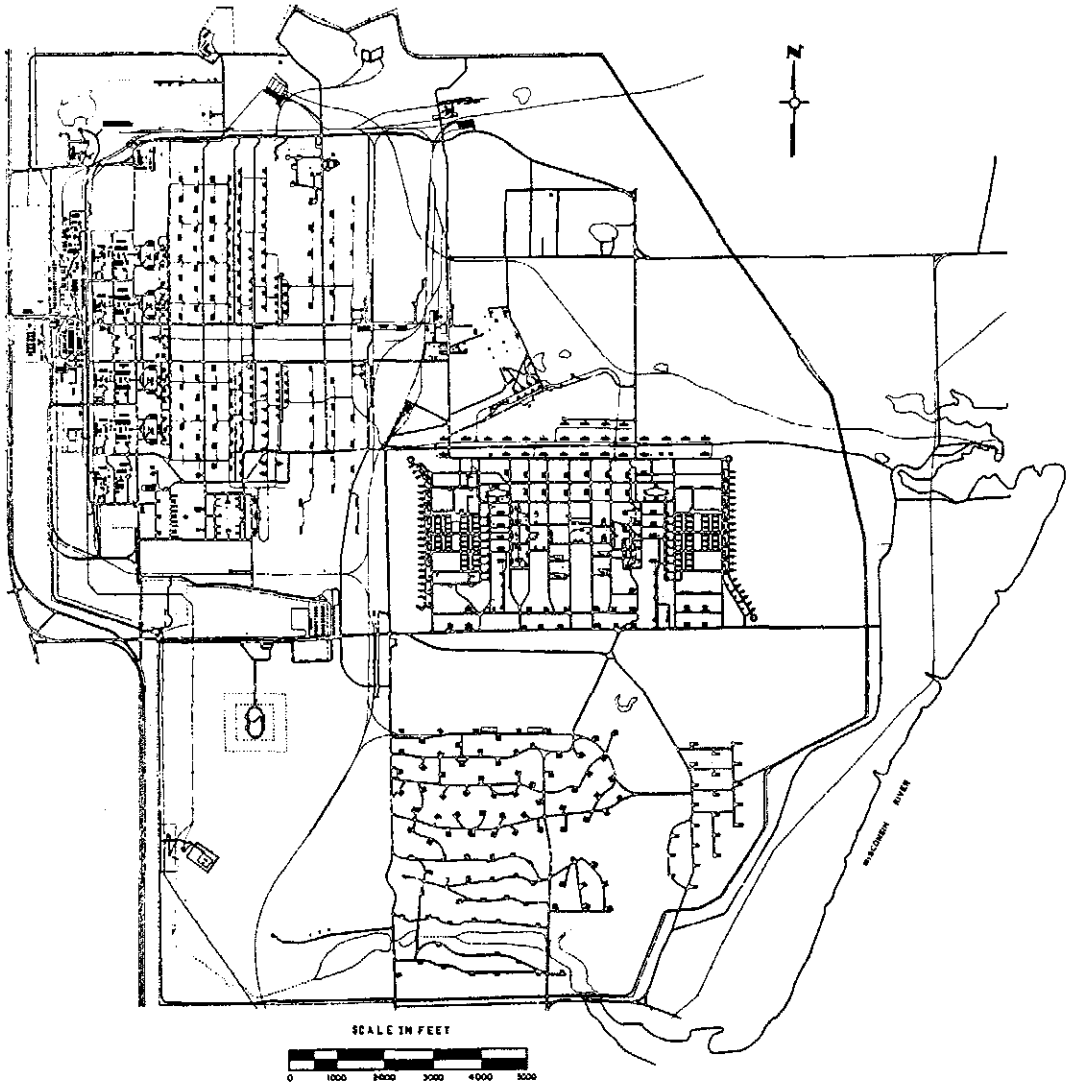

Figure 1: Site plan. (Source: Drawing files, BAAP)

> line to form a curb. The sidewalls were framed with 2"x6" wood studs, 2'-0" on center, and enclosed with novelty [Dolly Varden] siding. Where spans would permit, wood rafters spaced 2'-0" on center were used in roof construction. Longer spans were constructed of light wood trusses, spaced 2'-0" on center. The roofs were sheathed with 7/8" T&G [tongue and groove] lumber covered with Class B roll roofing. The doors, windows, ventilators, etc., were of standard design and of a type that could be furnished by any mill. The interior was left unfinished, except for a rough concrete floor.[7]

Examples of buildings constructed in this manner were the Line Offices (Buildings 1975-1 to 8), Change Houses (Buildings 6532-1 to 20), Shops (Buildings 2547, 2549), and Storehouses (Building 2548), as well as the majority of small to medium sized utility structures throughout the site (Figure 2). Especially large buildings, such as the Boiling Tub and Poacher and Blender Houses (Buildings 2019, 2024), employed heavier mill-type construction, with wood columns and trusses on concrete foundations (Figure 3).

Buildings where acids and finished powder were handled had special interior details, including floor coverings of lead, Hubbelite, or conductive rubber, and sealed interior walls of transite or plywood. To avoid sparked fire hazards, electrical wires and fixtures were often mounted on a building's exterior, with light coming through ground glass windows. Typical buildings outfitted in this manner are the Glaze and Blend Houses (Buildings 1800-1 to 7), and the Rest Houses (Buildings 1750-1 to 29).

Buildings housing particularly hazardous production steps utilized various types of "blow-out" construction to confine or direct potential explosions. Parallel concrete or brick barrier walls typically divided these buidings

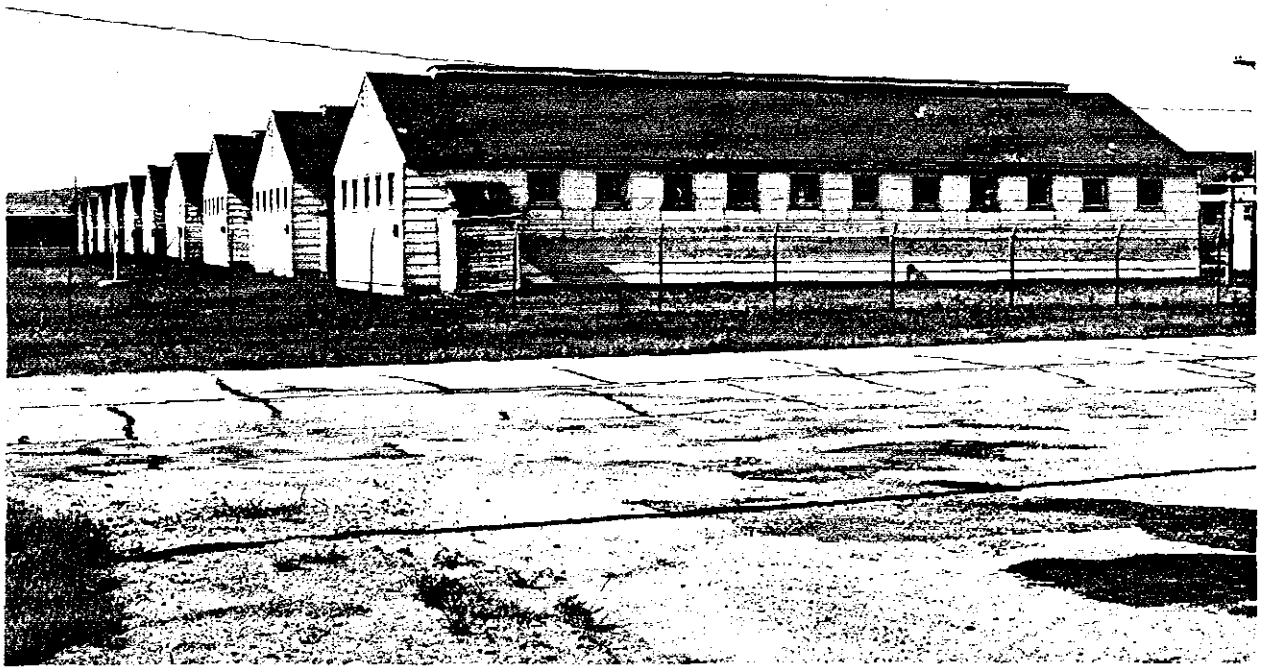

Figure 2: Typical small and medium scale wood-frame construction; Change Houses. (Source: Field inventory photograph, David Fey, MacDonald and Mack Partnership, 1983)

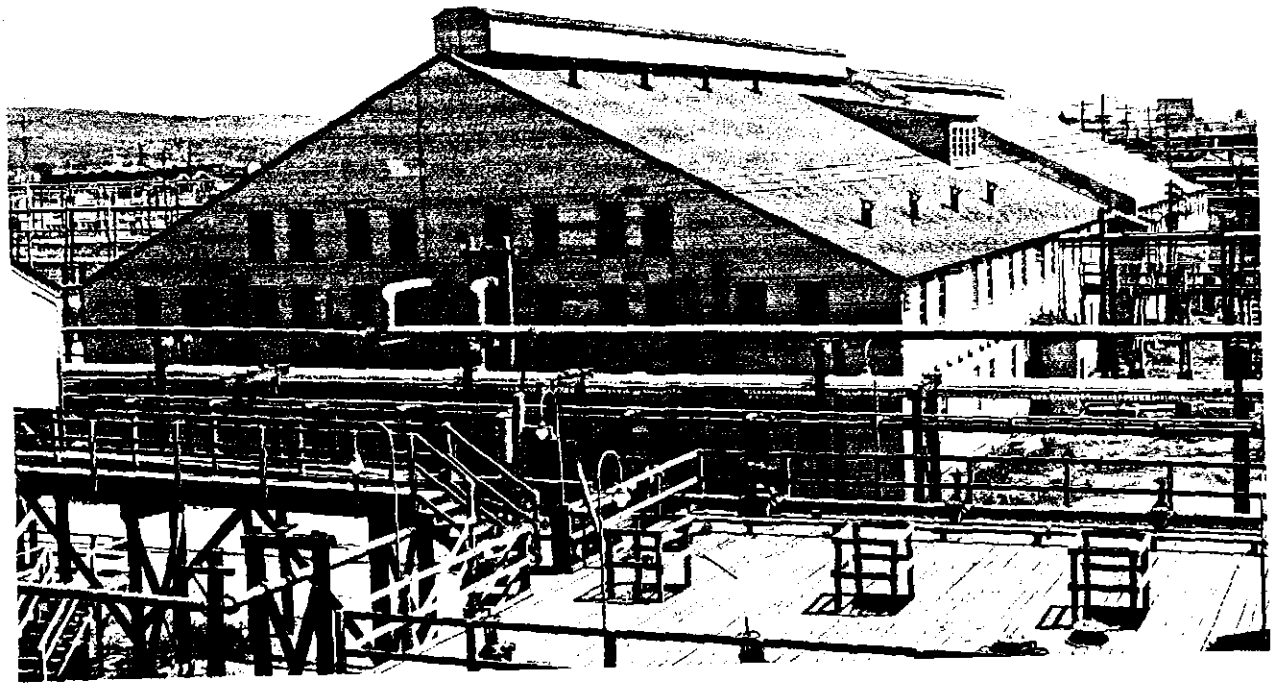

Figure 3: Typical large scale wood-frame construction; Poacher and Blender House. (Source: Field inventory photograph, David Fey, MacDonald and Mack Partnership, 1983)

into equipment bays. Light wood-frame infill construction, designed to blow out during an explosion, directed the thrust away from the adjacent bays. Buildings constructed in this manner included the Vertical Press (Buildings 2513-1 to 4), Solvent Recovery (Buildings 1600-1 to 42), Air Dry (Buildings 1725-1 to 17), and Final Mix Houses (Buildings 1825-1 to 4; Figure 4). Only the Powerhouse (Building 400) and Nitrating Houses (Buildings 2012, 3012, 4012, 5012, 9012) employed steel skeleton construction; they were faced with ceramic tile and brick, respectively (Figure 5). The acid and solvent production areas consisted mainly of large wood-frame structures of the type described above, in combination with vast networks of piping and holding tanks. An example of this type of construction is the Oleum Manufacturing Plant (Building 728-2; Figure 6).

The first acid production area was operational by January, 1943, with the smokeless powder production lines following shortly thereafter. Change orders issued frequently during the first phase of construction called for additional construction and the modification of existing plans. Additional acid facilities and production lines for single- and double-base powder and TNT were planned. When construction was halted on August 13, 1945, facilities for the production of nitric and sulphuric acid, nitroglycerine, single and double-base smokeless powder, and various solvents were complete and operational. A fifth smokeless powder line and the TNT facilities were left partially completed.[8]

Technology

The production of smokeless powder at the BAAP was based on the following process developed by the Dupont Corporation during the First World War[9]:

Figure 4: Typical concrete and wood-frame "blow-out" construction; Dehydrating Press House. (Source: Field inventory photograph, David Fey, MacDonald and Mack Partnership, 1983)

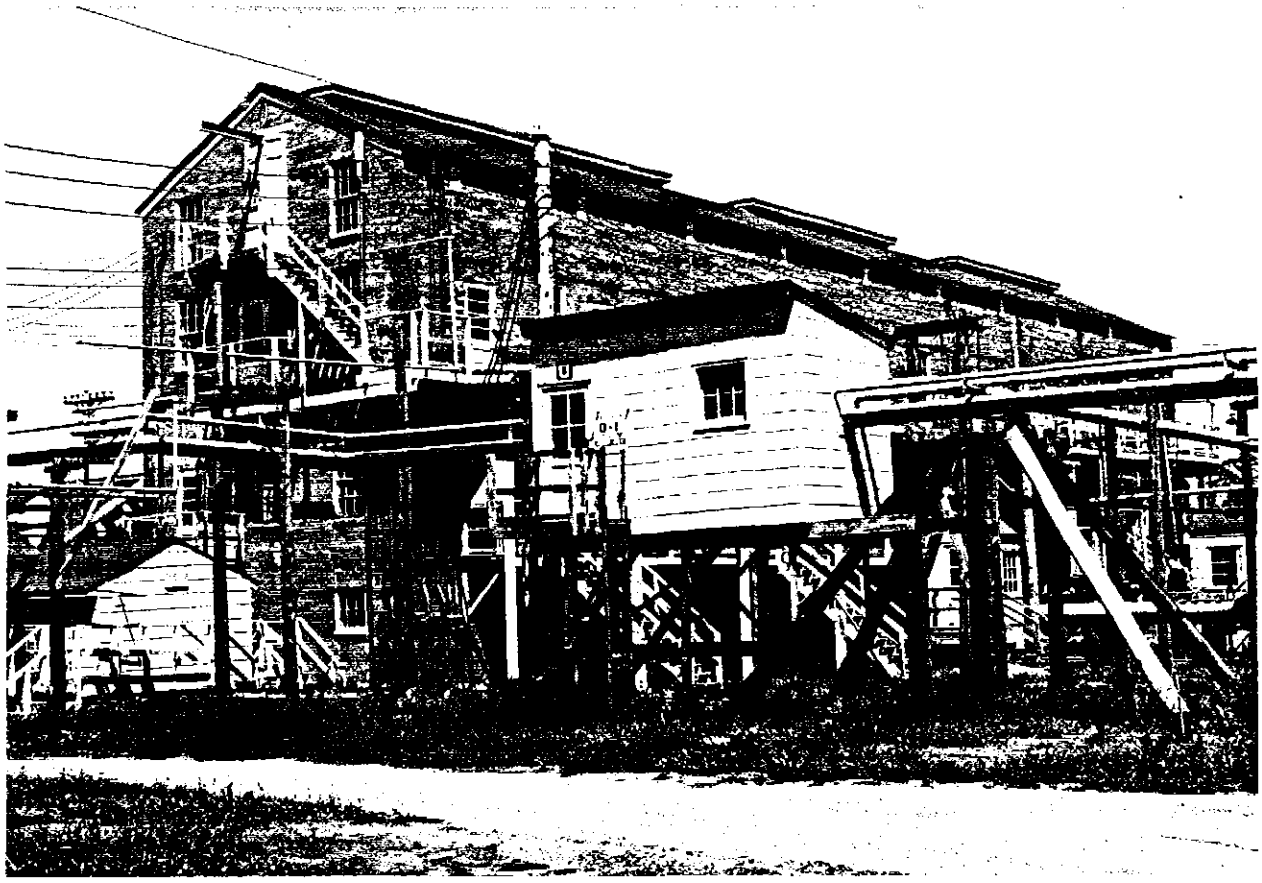

Figure 5: Typical steel frame and masonry construction; Nitrating House. (Source: Field inventory photograph, David Fey, MacDonald and Mack Partnership, 1983)

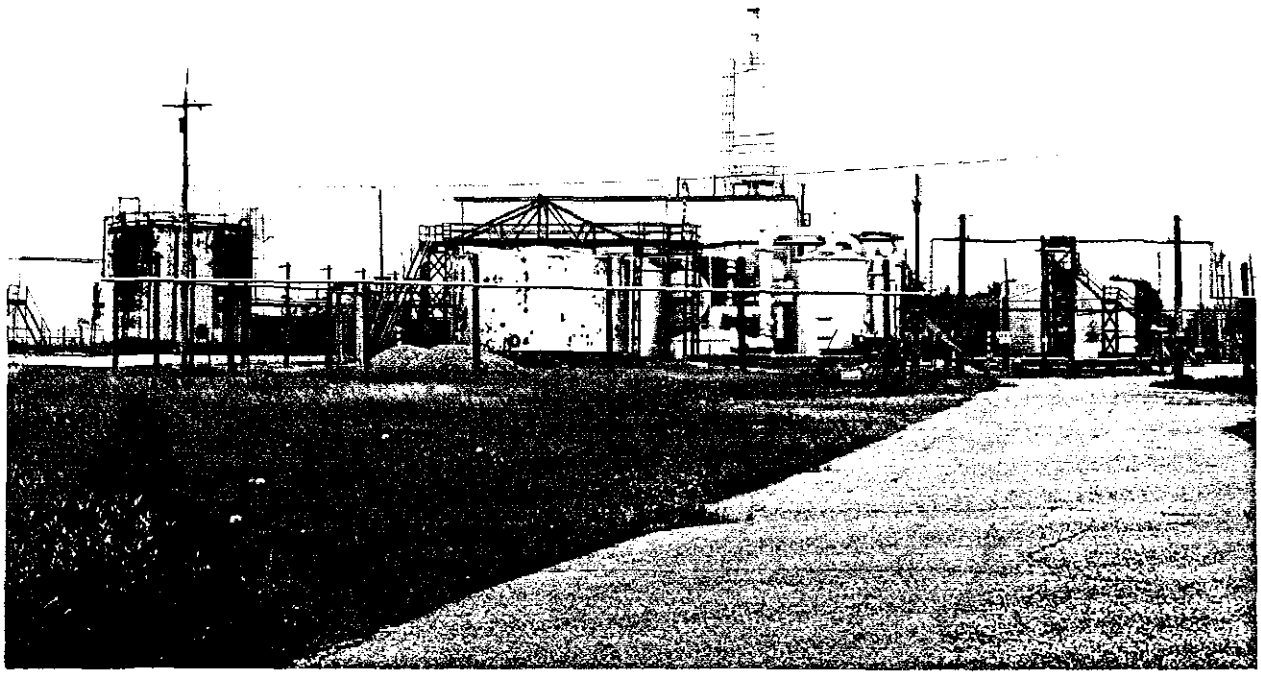

Figure 6: Typical chemical processing area; Oleum Manufacturing Plant. (Source: Field inventory photograph, David Fey, MacDonald and Mack Partnership, 1983)

The manufacturing process starts with the manufacture of 98% nitric acid, using the ammonia oxidation process, and the manufacture of 40% oleum (fuming sulphuric acid) by the contact process. The strong acids are mixed to make nitrating compositions suitable for nitrating chemical cellulose (of cotton linters or wood pulp origins) and natural or synthetic glycerin to make military grades of nitrocellulose and nitroglycerin, respectively. These intermediates, after purification, constitute the energy components of the end product propellants.

In the manufacture of single-base smokeless powder for artillery, nitrocellulose is compounded with solvents and modifying additives to form a rubbery paste in sigma-blade mixers. The colloided material is more intensively mixed in macerators and transferred to blocking presses which form the unconsolidated mix into cylindrical blocks for easy handling. The blocks are placed in hydraulic extrusion presses and extruded into perforated strands, which are cut into "grains." The solvent-laden cut powder goes through successive steps to remove the solvents (which are recovered and rectified for reuse), reduce residual solvent by soaking in hot water, and remove excess water by drying in an air stream. The dry powder is blended, tested for performance characteristics in a closed ballistics bomb and, when approved, packed into suitable shipping containers.

In the manufacture of solventless double-base rocket propellant, nitrocellulose and nitroglycerin, with other chemical additives, are mixed in a water slurry. The slurry is dewatered in centrifuges and the resultant "paste" is air dried to a predetermined moisture level. The damp paste is consolidated in roll mills into a rubbery sheet form. The sheet stock is tested for burning rate characteristics. Proved material is slit and rolled into "carpet rolls" suitable for charging into a high-pressure oildraulic extrusion press. The powder is extruded into final perforated grain form. The strand is cut into an approximate finished length. Rough grains are machined in successive steps to exact final weight and dimensions. Ethyl cellulose inhibitors are cemented to the ends of the grains and a spirally-wrapped multi-layer sleeve of ethyl cellulose tape is applied. The inhibited grains are cured under mild temperature and a final trimming operation is performed. Samples of the finished grain are static tested to establish ballistic characteristics. Acceptable grains are packed in protective tubes and bundled into pallet containers for shipment.[10]

The acid area at BAAP (Buildings 700-768) produced nitric acid and oleum. Cotton linters and wood pulp were nitrated in five identical Nitrating Houses (Buildings 2012, 3012, 4012, 5012, 9012). The resulting nitrocellulose was then transformed into either single-base smokeless

powder, in one of four identical production lines (the B, C, D, and E lines); or double-base smokeless powder (rocket propellant) in one of two identical production lines (the east and west rocket lines).

The major production buildings of the D line (4000-series building numbers) are typical of single-base smokeless facilities at the BAAP. Following nitration, the nitrocellulose was pumped through a flume line to large wooden tubs in the Boiling Tub House (Building 4019), where it was heated and agitated for about 40 hours. It was then piped to the Beater House (Building 4022) for processing in Jordan beaters, which reduced the mass to a suspension of finer particles. Next the suspension was boiled in a sequence of neutral and alkaline solutions in the Poacher and Blender House (Building 4024), washed with clear water, and screened for foreign matter. Moved by water slurry to the Wringer House (Building 4026), the suspension was dewatered in electric spinwringers. This concluded the manufacture of "pyrocotton."

This material was moved by drums on a Telpher conveyor system to the hydraulic presses in the Dehydrating Press House (Building 4500) where alcohol was injected into the pyrocotton, removing approximately 90% of the remaining water. The resulting cylinders were loaded on carts and wheeled to the Mix House (Building 4508), where they were broken apart in macerators, and mixed with diphenylamine (a chemical stabilizer) and additional alcohol. This dough-like mass was then extruded through a "macaroni" press and formed again into cylinders in block presses in the Block Press House (Building 4510). This concluded the colloiding process.

The colloided pyrocotton cylinders were moved by cart to the Vertical Press House (Building 4513), where they were forced through changeable steel dies to produce a variety of solid or perforated strands. These strands were cut to precise lengths in the adjacent Cutting House (Building 4516). The finished "grains" were then conveyed by tram railway to the final processing area.

The final processing area (1600, 1700, 1800, and 1900-series buildings) served all four of the single-base smokeless lines. In the Solvent Recovery Houses (Buildings 1600-1 to 42), batches of finished grains were heated, and solvent (alcohol) vapors recovered. Boiling in the Water Dry Houses (Buildings 1650-1 to 42) removed additional solvent and hardened the grains. The grains were then coated with chemical modifiers in the Coating Houses (Buildings 1700-1 to 12), and dried by forced air in the Air Dry Houses (Buildings 1725-1 to 17). The dried grains were then stored in Rest Houses (Buildings 1750-1 to 29) while ballistics tests determined their burning characteristics. Selective coating and blending of batches then took place in the Glaze and Blend Houses (Buildings 1800-1 to 8, 1810-1 to 4, and 1825-1 to 4). Following additional testing, approved batches were loaded for shipment in the Can Pack Houses (Buildings 1875-1 to 4). Powder that was not shipped immediately was stored in the Powder Magazines (Buildings 1900-1 to 8, 1906-1 to 56, and 1932-1 to 34).

The major production buildings of the west rocket area are typical of double-base smokeless powder facilities at the BAAP. Nitrocellulose from the Nitrating Houses was mixed with nitroglycerine in a water slurry in the Mix Houses (Buildings 6702-1 to 4, and 6704-1 to 4). The slurry was

dewatered in centrifuges in the Pre Dry Houses (Buildings 6709-1 to 28), and blended into a uniform paste in the Paste Breaker and Blender Houses (Buildings 6731-2 to 4). The paste was then rolled into sheets in the Roll Houses (Buildings 6807-1 to 61), which were cut to size and rolled into cylinders in the Slitting and Carpet Roll Houses (Buildings 6808-1 to 16). These rolls were then extruded through horizontal presses into single, perforated grains in the Press Houses (Buildings 6810-1 to 44). Final milling, inspection, and packing took place in the Milling Houses (Buildings 6814-1 to 10), Inspection Houses (Buildings 6816-1 to 10), and Packing Houses (Buildings 6817-1 to 4).

Total production of single- and double-base powder during World War II exceeded 260 million pounds.[11] The government placed BAAP on standby status on September 7, 1945, reducing the staff to a small force of government employees and Operating Contractor standby personnel.

KOREAN WAR PERIOD

In February 1951, the Corps of Engineers authorized the Fegles Construction Company of Minneapolis, Minnesota to rehabilitate the plant for activation during the Korean War. The Liberty Powder Defense Corporation, a subsidiary of Olin Corporation, succeeded the Hercules Powder Company as the operating contractor on the site in March 1951. Extrusion and finishing of rocket propellant was underway by September 1951, and the plant was fully operational on a continuous basis three months later. Production at that time included a variety of single and double-base propellants, as well as the necessary component acids and solvents.[12]

In the summer of 1952, the BAAP was first considered for the installation of facilities to produce "Western Ball Powder" -- a revolutionary type of smokeless powder developed in the 1930's by the Western Cartridge Company of East Alton, Illinois, a subsidiary of Olin Corporation.[13] In the Western process, smokeless powder was handled in a water-based slurry throughout most of the stages of production, eliminating the wringing, shredding, pressing, extruding, and cutting stages of conventional smokeless powder production.

Western Cartridge first produced "Ball Powder" on a large scale in the 1940s, and the U.S. Army purchased the product in increasing quantities for use in rifle ammunition. Military demand for the new powder grew dramatically during the Korean War, and in March 1954 designs for the new facility at the BAAP were approved.[14]

Construction

The H. K. Ferguson Company of Cleveland, Ohio completed the new facilities in July 1955. The buildings were unlike any others on the site. Constructed of poured, reinforced concrete slabs and columns, they were enclosed by glass and steel infill panels with diagonal steel tension straps to provide lateral stability. Examples of this construction type are the Solvent Receiving (Buildings 9502-1 to 6), Wet Screening (Building 9503), and Coating Houses (Buildings 9506-1 & 2; Figure 7).[15]

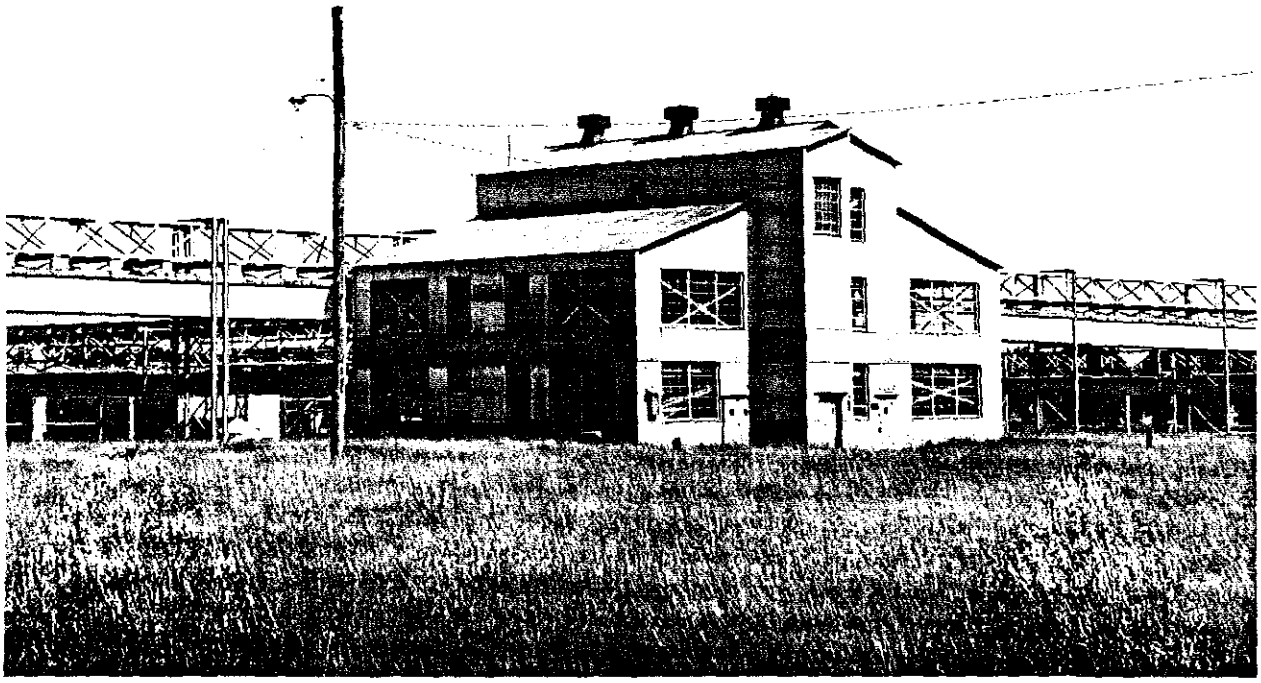

Figure 7: Typical reinforced concrete construction with glass and steel infill; ball powder Hardening and Weighing House. (Source: Field inventory photograph, Robert Ferguson, MacDonald and Mack Partnership, 1983)

Technology

The production of double-base smokeless Ball Powder at the BAAP followed the steps developed at Western Cartridge:

> The production of Ball Powder propellant, an Olin development... starts in a water slurry medium. Nitrocellulose, in a slurry with other ingredients and ethyl acetate solvent, is reduced to a lacquer form in agitated vessels. By controlled agitation and the successive addition of protective colloid and dewatering salt, the lacquer is dispersed into droplets of suitable diameter. The solvent is distilled off, leaving round hard balls of stabilized nitrocellulose in a water suspension. The unclassified balls are separated into sharply controlled granulation "cuts" by wet screening. The classified material in slurry form is impregnated with nitroglycerin and coated with dibutylphalate, an inert ballistic modifier, to control the burning rate. The coated material is dewatered in a continuous centrifuge, air dried, glazed with graphite (to improve loading characteristics and reduce static hazards), and blended. The finished product is extensively tested for ballistics performance characteristics. Final blending accomplishes uniformity, and the powder is packed into shipping containers.[16]

The production of Ball Powder at the BAAP began in the Hardening Weigh and Solvent Receiving Houses (Buildings 9500-1 to 3, 9501-1 to 3, and 9502-1 to 6), where nitrocellulose was weighed, mixed in a water slurry with chemical modifiers and ethyl acetate solvent, agitated to produce droplets of the desired size, and stabilized by the addition of protective colloids, which hardened the floating droplets. The slurry then passed through a series of screens in the Wet Screening House (Building 9503), that separated the droplets into batches of nearly identical diameter. These sized batches were coated with chemical modifiers and nitroglycerine in the Coating Houses (Buildings 9506-1 and 2, and 9507-1 to 8). The slurry was dewatered in the Roll and Dewater Houses (Buildings 9509-1 and 2) and the finished balls were dried in the Tray Dry Houses (Buildings 9513-1 to 3).

The Ball Powder process had several advantages. The powder's slurry form, maintained during most of the process, greatly reduced chances of accidental explosion and eased transport of the material between production stages. The process also offered very precise control of grain size and shape, making for a uniform, predictable, propellant. But the most dramatic advantage was increased speed: finished powder could be produced in one-fifth the time previously required. The BAAP remains the only government-owned plant with complete facilities for smokeless Ball Powder production.[17]

Production during the Korean War included the products previously manufactured, with the addition of Ball Powder. Total production of single-base, double-base, and Ball Powder during the Korean War exceeded 280 million pounds.[18] On March 1, 1958, the BAAP returned to standby status, with the Olin Corporation providing maintenance.

VIETNAM WAR TO THE PRESENT

On January 3, 1966,the Olin Corporation reactivated the plant. It readied the Ball Powder area for operation by June 1966, and the rocket area and single-base smokeless powder areas by September 1966 and August 1967, respectively. The plant's total production of single-base, double-base, and Ball Powder during the Vietnam War exceded 440 million pounds. All production at the BAAP ceased by June 1975, and the plant has remained on standby and modernization status, under the management of Olin Corporation, since that time.[19]

Construction and Technology

A modernization program begun in June 1972 has included the rehabilitation of numerous facilities, as well as limited new construction (primarily in response to increasingly stringent pollution control regulations). A new acid complex constructed in the early 1970's includes weak nitric, oleum, and nitric-sulphuric acid concentration facilities (Buildings 750-793), and a number of acid and contaminated waste treatment facilities have been constructed since the mid 1970s (not yet numbered). Rehabilitation of water and steam lines, as well as selected powder production equipment, continues at this time.[20]

Originally, each production building handling nitrocellulose was surrounded by a Repauno-type mud-sill barricade of heavy timber construction filled with sifted earth or sand, and reaching to the eave line of the contained structure. Following a change in safety regulations, most of these barricades were removed (Figure 8).[21] Other alterations since 1942-1945 have included the installation of asbestos siding over the original wood siding, and the installation of asphalt shingle roofing on virtually every frame building. These measures have not altered significantly the World-War-II- and Korean-War-era construction and technology at the BAAP.

The BAAP currently employs approximately 400 staff members, and is managed by Olin Corporation as a government-owned, contractor-operated propellant production facility under the jurisdiction of the Headquarters, U.S. Army Armament, Munitions and Chemical Command (AMCCOM).

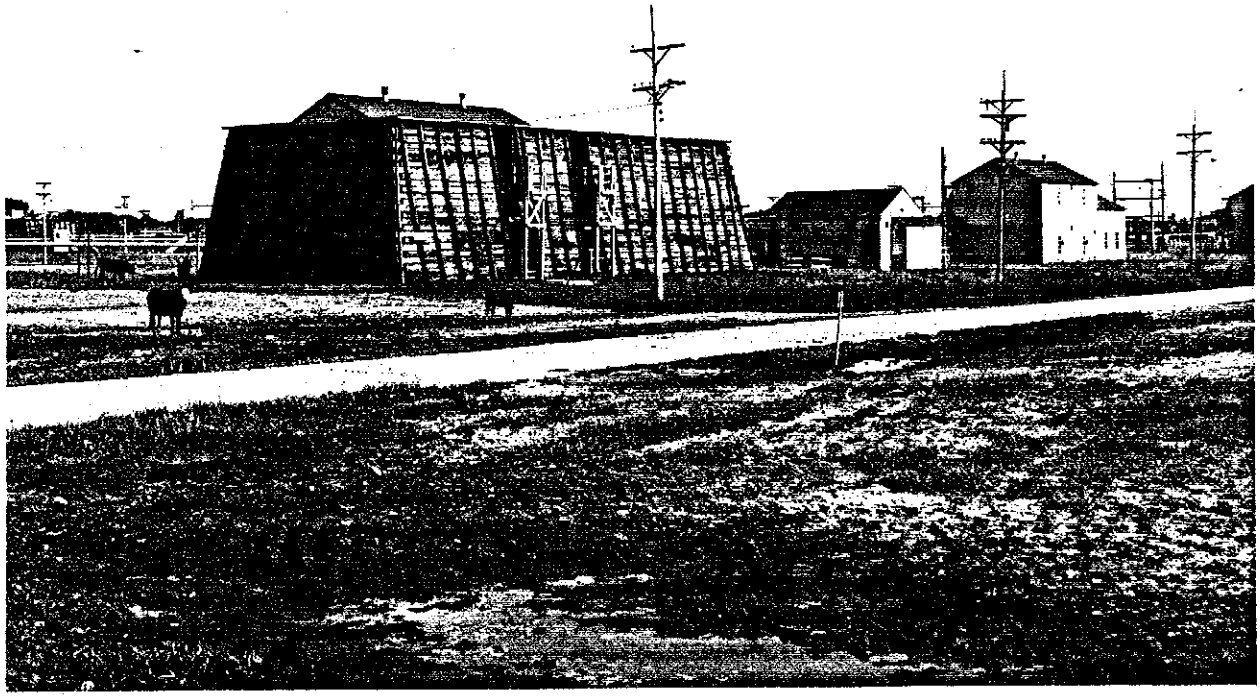

Figure 8: Typical earth and timber barricade; Water Dry House. Building to right is identical, without barricade. (Source: Field inventory photograph, David Fey, MacDonald and Mack Partnership, 1983)

NOTES

1. Hercules Powder Company, Report of Badger Ordnance Works, WW II (Baraboo, Wisconsin: October, 1945), p.18.

2. Government criteria for the selection of ammunition plants are described in Harry C. Thompson and Linda Mayo, The Ordnance Department: Procurement and Supply (Washington: 1960), p.108.

3. Nearly identical plants were constructed near Radford, Virginia (Radford Army Ammunition Plant), in 1940-41, and Desoto, Kansas (Sunflower Army Ammunition Plant), in 1942-43. Although standard building plans and plant layouts were used by Hercules for all three plants, local variations in availability of materials and site geography led to minor variations. Three additional GOCO smokeless powder plants were constructed during the same period under the direction of Dupont Corporation at Sylacauga, Alabama; Charlestown, Indiana; and Choteau, Oklahoma.

4. David P. Mayer, Corps of Engineers Historical Record: Badger Ordnance Works (Baraboo, Wisconsin: December, 1942), p.34.

5. Ibid., p.5.

6. Badger Army Ammunition Plant, Narrative Descriptive Presentation (Baraboo, Wisconsin: n.d.), pp.5-6.

7. Report of Badger Ordnance Works..., pp.52-53.

8. Badger Army Ammunition Plant, Historical Summary: 1942-1967 (Baraboo, Wisconsin: 1967), p.8.

9. The standard Dupont process for the nitration of celulose fiber and its extrusion into propellant grains is clearly described in the following articles: "Mid-West Builds Biggest U.S. Powder Plant," Chemical and Metallurgical Engineering, (April 1941), 73-6; "Producing Smokeless Powder by 1942 Methods," Chemical and Metallurgical Engineering, (April 1942), 76-9.

10. Narrative..., p.6.

11. Badger Army Ammunition Plant, Memorandum for Record: Badger Army Ammunition Plant 2ND QTR FY 83, Plant Profile Review (Baraboo, Wisconsin: March, 1983), p.3.

12. Badger Ordnance Works, Semi-Annual Historical Summary (Baraboo, Wisconsin: 1951), pp.5-6.

13. The development of Ball Powder is attributed to Frederich Olsen, Gordon C. Tibbitts, and Edward B.W. Kerone, of the Western Cartridge Company, in whose names the invention was patented on January 7, 1936, U.S. patent #2,027,114. The first powder was produced at Western's

plant in East Alton, Illinois in September 1940. Prior to the construction of the Ball Powder facilities at BAAP, the government bought the product directly from private industry. A number of articles describing the process appeared in the early 1940's: "Water Process Cuts Smokeless Production Time 90 Per Cent," Chemical Industries, (December 1944), 915; "Smokeless Powder Balls," Chemical and Metallurgical Engineering, (May 1943), 206-7; "Ball Powder: Smokeless Powder Now Made Under Water," Scientific American, (August 1943), 59.

14. Badger Ordnance Works, Semi-Annual Historical Summary (Baraboo, Wisconsin: 1953), p.1.

15. Badger Ordnance Works, Semi-Annual Historical Summary (Baraboo, Wisconsin: 1954), p.1.

16. Narrative..., p.6.

17. Badger Ordnance Works, Semi-Annual Historical Summary (Baraboo, Wisconsin: 1955), p.3; Modernization Engineering Report for U.S. Army Ammunition Plants (Baraboo, Wisconsin: August 1970), p.111-115.

18. Memorandum..., p.3.

19. Ibid., p.3.

20. Badger Army Ammunition Plant, DARCOM Installation and Activity Brochure (Baraboo, Wisconsin: 1980), p.1.

21. According to Don Stoll, who guided the plant inspection, the earth-filled barricades were removed during the 1960s, when safety regulations were amended and no longer required them.

Chapter 3

PRESERVATION RECOMMENDATIONS

BACKGROUND

Army Regulation 420-40 requires that an historic preservation plan be developed as an integral part of each installation's planning and long-range maintenance and development scheduling.[1] The purpose of such a program is to:

- Preserve historic properties to reflect the Army's role in history and its continuing concern for the protection of the nation's heritage.
- Implement historic preservation projects as an integral part of the installation's maintenance and construction programs.
- Find adaptive uses for historic properties in order to maintain them as actively used facilities on the installation.
- Eliminate damage or destruction due to improper maintenance, repair, or use that may alter or destroy the significant elements of any property.
- Enhance the most historically significant areas of the installation through appropriate landscaping and conservation.

To meet these overall preservation objectives, the general preservation recommendations set forth below have been developed:

Category I Historic Properties

All Category I historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for

nomination regardless of age. The following general preservation recommendations apply to these properties:

a) Each Category I historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category I historic properties should not be altered or demolished. All work on such properties shall be performed in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation (ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).

b) An individual preservation plan should be developed and put into effect for each Category I historic property. This plan should delineate the appropriate restoration or preservation program to be carried out for the property. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulation. Until the historic preservation plan is put into effect, Category I historic properties should be maintained in accordance with the recommended approaches of the Secretary of Interior's Standards for Rehabilitation and

Revised Guidelines for Rehabilitating Historic Buildings[2] and in consultation with the State Historic Preservation Officer.

c) Each Category I historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.[3] When no adequate architectural drawings exist for a Category I historic property, it should be documented in accordance with Documentation Level I of these standards. In cases where standard measured drawings are unable to record significant features of a property or technological process, interpretive drawings also should be prepared.

Category II Historic Properties

All Category II historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for nomination regardless of age. The following general preservation recommendations apply to these properties:

a) Each Category II historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category II historic properties should not be altered or demolished. All work on such properties shall be performed

in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation (ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).

b) An individual preservation plan should be developed and put into effect for each Category II historic property. This plan should delineate the appropriate preservation or rehabilitation program to be carried out for the property or for those parts of the property which contribute to its historical, architectural, or technological importance. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulations. Until the historic preservation plan is put into effect, Category II historic properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings[4] and in consultation with the State Historic Preservation Officer.

c) Each Category II historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level

II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.[5]

Category III Historic Properties

The following preservation recommendations apply to Category III historic properties:

a) Category III historic properties listed on or eligible for nomination to the National Register as part of a district or thematic group should be treated in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800). Such properties should not be demolished and their facades, or those parts of the property that contribute to the historical landscape, should be protected from major modifications. Preservation plans should be developed for groupings of Category III historic properties within a district or thematic group. The scope of these plans should be limited to those parts of each property that contribute to the district or group's importance. Until such plans are put into effect, these properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised

Guidelines for Rehabilitating Historic Buildings[6] and in consultation with the State Historic Preservation Officer.

b) Category III historic properties not listed on or eligible for nomination to the National Register as part of a district or thematic group should receive routine maintenance. Such properties should not be demolished, and their facades, or those parts of the property that contribute to the historical landscape, should be protected from modification. If the properties are unoccupied, they should, as a minimum, be maintained in stable condition and prevented from deteriorating.

HABS/HAER Documentation Level IV has been completed for all Category III historic properties, and no additional documentation is required as long as they are not endangered. Category III historic properties that are endangered for operational or other reasons should be documented in accordance with HABS/HAER Documentation Level III, and submitted for inclusion in the HABS/HAER collections in the Library of Congress.[7] Similar structures need only be documented once.

CATEGORY I HISTORIC PROPERTIES

There are no Category I historic properties at the BAAP.

CATEGORY II HISTORIC PROPERTIES

There are no Category II historic properties at the BAAP.

CATEGORY III HISTORIC PROPERTIES

Ball Powder Facilities

(Buildings 9500-1 to 3, 9501-1 to 3, 9502-1 to 6, 9503, 9507-1 to 8, 9509-1 & 2, 9591, 9592, 9593, and 9594)

- Background and significance. The Western Cartridge Company, a division of the Olin Corporation, designed the Ball Powder method in the early 1930s, and in 1954-55 the BAAP became the first GOCO facility to adopt this process. The new method was faster, safer, and produced more uniform powder than standard smokeless powder production methods. (See description of process in Chapter 2.) The facilities were modified somewhat during reactivation for the Vietnam War, but remain substantially as originally constructed. Although they do not satisfy the National Register of Historic Places requirements for buildings less than fifty years old, the major production buildings in the Ball Powder area at the BAAP are Category III historic properties because they are a good example of a highly intact industrial process, and constitute the only such facilities at a GOCO plant in the United States.

- Condition and potential adverse impacts. The Ball Powder facilities at the BAAP are in good condition, and undergo routine maintenance and

repair as part of standby activity at the plant. There are currently no plans that would have an adverse impact on the property.

- Preservation options. The Ball Powder facilities at the BAAP should be maintained in accordance with the Preservation Recommendations for Category III historic properties described above.

NOTES

1. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).
2. National Park Service, Secretary of Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings, 1983 (Washington, D.C.: Preservation Assistance Division, National Park Service, 1983).
3. National Park Service, "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines," Federal Register, Part IV, 28 September 1983, pp. 44730-44734.
4. National Park Service, Secretary of the Interior's Standards.
5. National Park Service, "Archeology and Historic Preservation."
6. National Park Service, Secretary of the Interior's Standards.
7. National Park Service, "Archeology and Historic Preservation."

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